US009470218B2

(12) United States Patent
Eowsakul

(10) Patent No.: US 9,470,218 B2
(45) Date of Patent: Oct. 18, 2016

(54) SELF-COOLING LOOP WITH ELECTRIC RAM FAN FOR MOTOR DRIVEN COMPRESSOR

(71) Applicant: **HAMILTON SUNDSTRAND CORPORATION**, Windsor Locks, CT (US)

(72) Inventor: **Vanwijak Eowsakul**, Holyoke, MA (US)

(73) Assignee: **Hamilton Sundstrand Corporation**, Windsor Locks, CT (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 430 days.

(21) Appl. No.: **13/889,499**

(22) Filed: **May 8, 2013**

(65) **Prior Publication Data**

US 2014/0331692 A1 Nov. 13, 2014

(51) **Int. Cl.**
F25B 9/00 (2006.01)
F04B 39/06 (2006.01)

(52) **U.S. Cl.**
CPC ***F04B 39/066*** (2013.01)

(58) **Field of Classification Search**
CPC F25B 9/004; F25B 9/00; F04B 39/06
USPC 62/56, 401, 402, 244
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,131,225	A *	7/1992	Roettger	60/785
6,928,832	B2 *	8/2005	Lents et al.	62/401
6,981,388	B2 *	1/2006	Brutscher et al.	62/401
7,342,332	B2	3/2008	McAuliffe et al.	
7,625,434	B2	12/2009	Tom et al.	
8,079,407	B2 *	12/2011	Fellague et al.	165/140
8,500,878	B2 *	8/2013	Cremers et al.	96/109
8,656,912	B2 *	2/2014	Johannessen	128/204.15
2004/0261428	A1 *	12/2004	Murry et al.	62/86
2005/0151019	A1	7/2005	Stevens	
2005/0223895	A1	10/2005	Wong	
2007/0113579	A1 *	5/2007	Claeys et al.	62/401
2007/0158122	A1 *	7/2007	Telakowski	180/68.1
2008/0060523	A1 *	3/2008	Tom et al.	96/109
2008/0110603	A1 *	5/2008	Fellague et al.	165/140
2010/0072837	A1 *	3/2010	Telakowski	B64F 1/362 310/59

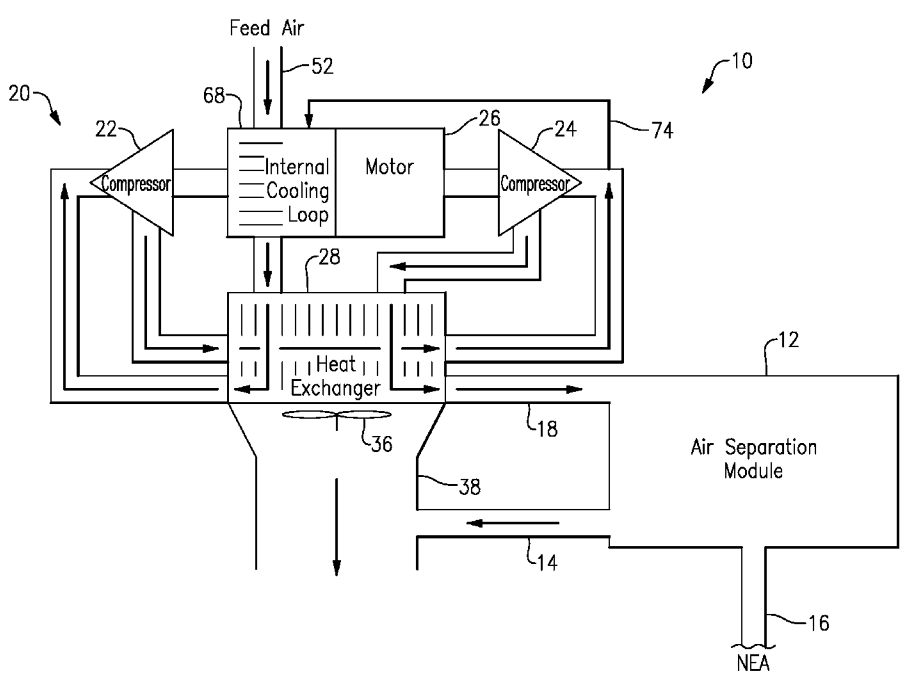
* cited by examiner

Primary Examiner — Mohammad M Ali
(74) *Attorney, Agent, or Firm* — Carlson, Gaskey & Olds, PC

(57) **ABSTRACT**

A motor driven compressor system includes a motor with an internal cooling loop. The internal cooling loop draws cooling air from outside the motor driven compressor system. At least one compressor is driven by the motor. A heat exchanger is in fluid communication with the at least one compressor and the cooling loop and is arranged in a ram air duct. An on board inert gas generating system (OBIGGS) for a gas turbine engine and a method of cooling the system utilizing such a compressor system are also disclosed.

20 Claims, 3 Drawing Sheets



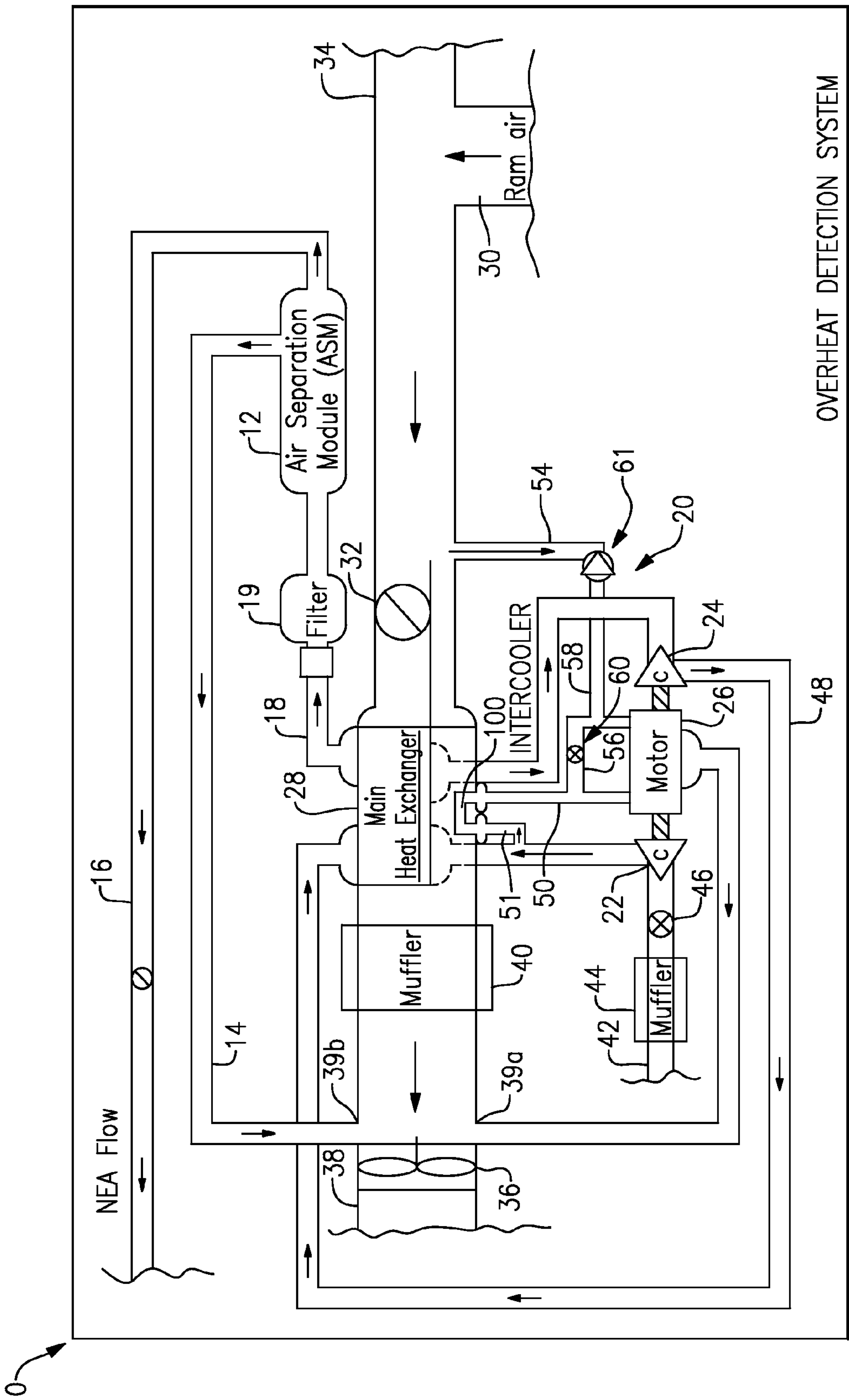


FIG. 1
Prior Art

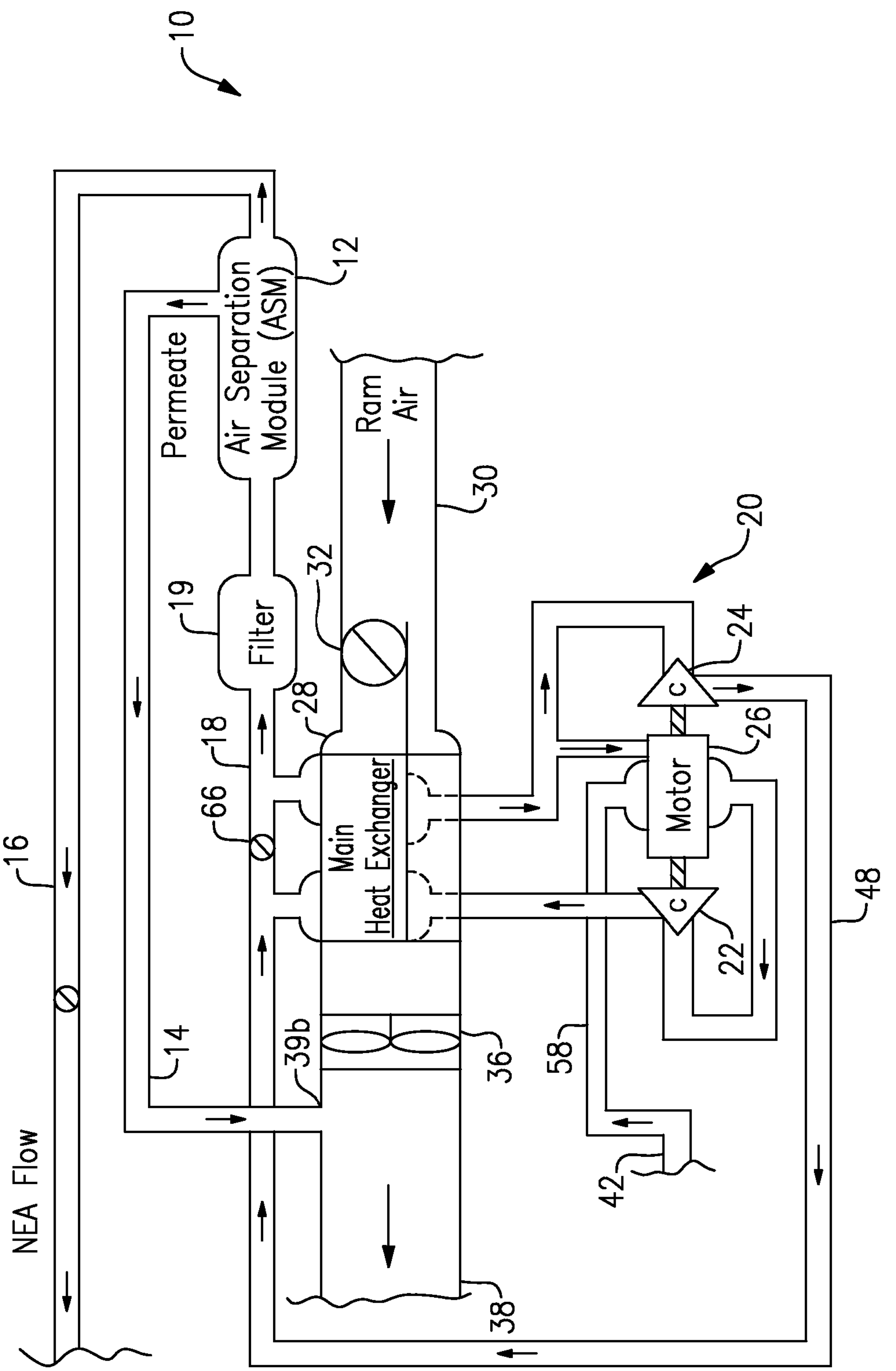


FIG.2
Prior Art

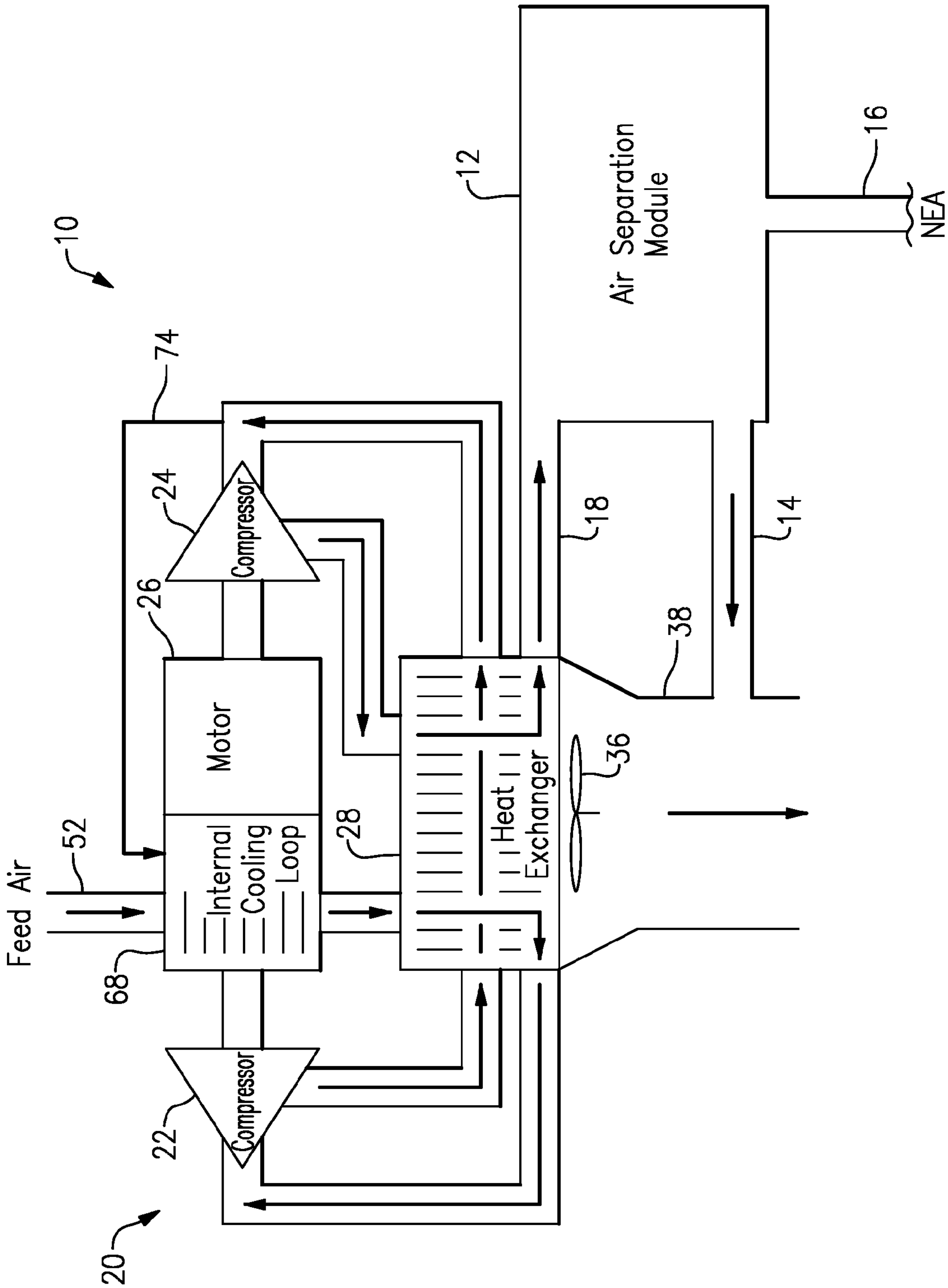

Feed Air
Internal Cooling Loop
Motor
Compressor
Compressor
Heat Exchanger
Air Separation Module
NEA
10
12
14
16
18
20
22
24
26
28
36
38
52
68
74

FIG.3

SELF-COOLING LOOP WITH ELECTRIC RAM FAN FOR MOTOR DRIVEN COMPRESSOR

BACKGROUND

This disclosure relates to a motor cooling system for a motor-driven compressor in an aircraft On Board Inert Gas Generating System (OBIGGS).

Aircraft and other vehicles may include an OBIGGS for generating inert gas. An OBIGGS generally includes an air separation module (ASM), which separates air into an inert nitrogen-enriched air (NEA) stream and a permeate oxygen enriched air (OEA) stream. The NEA stream may, for example, be used at the fuel tanks of an aircraft or vehicle.

OBIGGS designs may include a heat exchanger and a motor-driven compressor (MDC) system. The MDC system may include first and second compressors. The heat exchanger may be arranged in a ram-type air duct. During ground operation, cooling airflow over the heat exchanger is usually provided by an ejector downstream of the MDC system, which creates a low pressure area and draws air across the heat exchanger. The ejector air is generated from MDC second compressor outlet. During various flight and day temperatures (i.e., cold to hot day) conditions, the airflow over the heat exchanger may vary. For example, in the hot day condition there may not be enough airflow during ground operations to sufficiently cool the heat exchanger.

Additionally, the MDC is usually cooled by a cooling loop which may pass through an intercooler. Presently, the MDC cooling loop draws air from the outlet of the first compressor, and the air is ultimately discarded overboard after passing through the cooling loop. This lowers the efficiency of the MDC cooling loop during ground operations.

The ASM receives compressed air from the MDC. However, current MDC cooling designs do not effectively provide adequate ASM inlet temperature during cruising. Furthermore, the ejector can lower the flow rate of air available in the MDC system, which in turn decreases the amount of air available for the ASM.

SUMMARY

A motor driven compressor system includes a motor with an internal cooling loop. The internal cooling loop draws cooling air from outside the motor driven compressor system. The compressor system also includes at least one compressor driven by the motor and a heat exchanger in fluid communication with the compressor and the cooling loop. The heat exchanger is arranged in a ram air duct. An on board inert gas generating system (OBIGGS) and a method including the motor driven compressor system are also disclosed.

BRIEF DESCRIPTION OF THE DRAWINGS

The disclosure can be further understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

FIG. **1** schematically illustrates an example prior art ejectorless on board inert gas generating system (OBIGGS) with an electric fan and self-cooling motor driven compressor (MDC).

FIG. **2** schematically illustrates an alternate prior art OBIGGS with an electric fan and self-cooling MDC.

FIG. **3** schematically illustrates an alternate detail self-cooling MDC.

DETAILED DESCRIPTION

FIG. **1** shows an example schematic prior art ejectorless On Board Inert Gas Generating System (OBIGGS) **10**. The OBIGGS **10** includes an air separation module (ASM) **12**. As is known, the air separation module filters air into a permeate (oxygen enriched air, or OEA), which exits the ASM via a conduit **14**, and an inert nitrogen-right air (NEA), which exits the ASM via a conduit **16**. The ASM **12** receives cool air from a motor-driven compressor (MDC) system **20** via a conduit **18**. A filter **19** may filter the air in conduit **18** before it reaches the ASM **12**.

The MDC system **20** may include first and second compressors (C) **22** and **24**, a motor **26**, and a heat exchanger **28**. The heat exchanger may be an intercooler-type heat exchanger. That is, cooling fluid and fluid traveling through the MDC system **20** do not mix. The heat exchanger **28** cools air for the ASM **12** and the motor **26**. Cooling flow for the heat exchanger **28** is provided by a ram-type duct **30** in one example. Ram air flow may be controlled by a valve **32**. Additional cooling air may also be provided by an auxiliary inlet **34** extending through the skin of an associated aircraft. An electric fan **36** is arranged downstream of the heat exchanger **28** in an overboard exhaust **38**. A muffler **40** may be arranged downstream of the heat exchanger **28** as well.

The first and second compressors **22**, **24** are driven by the motor **26**. Air enters the MDC system **20** from an inlet **42**. This air may be from a cabin or cargo compartment of an aircraft. A second muffler **44** and/or a valve **46** may be arranged downstream of the MDC inlet **42**. Air is compressed by the first compressor **22** and sent to the heat exchanger **28**. Air from the heat exchanger **28** goes to the second compressor **24**. The flow passages for the system air within the heat exchanger **28** are not shown but would be apparent to a worker in the art. Air from the second compressor **24** cycles back to the heat exchanger **28** by the return line **48**. Air from line **48** enters the heat exchanger **28** to become temperature conditioned air **18** that feeds into the filter **19**. Air exiting from the motor **26** and permeate exiting from the ASM **12** via conduit **14** may feed into the overboard exhaust **38** at mixing points **39***a* and **39***b*, respectively. In the example shown in FIG. **1**, both mixing points **39***a*, **39***b* are upstream from the electric fan **36**.

The MDC system **20** includes a cooling loop **50**. Hot compressed air from the first compressor **22** is pushed through an intercooler **100** via a conduit **51**. The intercooler **100** feeds into the motor **26** for direct stator cooling. The hot compressed air is cooled by the heat exchanger **28** in the intercooler **100** and used to cool the motor **26**. During flight, valve **60** is closed. The cooling ram air may then be used to cool the motor **26** via conduit **54**. During ground operations, bearing and rotor cooling is provided by the stream **56** while check valve **61** is closed.

Referring to FIG. **2**, an alternate prior art OBIGGS **10** is schematically shown. In the alternate OBIGGS **10**, the mixing point **39***b* is downstream from the electric fan **36**. In this example, some air exiting from the second compressor **24** in the return line **48** may pass directly to the ASM **12** via conduit **18**.

The OBIGGS **10** may also include a temperature detection or regulation system. For example, in FIG. **1** the OBIGGS **10** includes an overheat detection system **64** integrated into the OBIGGS to ensure that the system components, for example, the first and second compressors

22, 24, do not exceed a predetermined threshold temperature which may affect operation of the MDC system 20. In FIG. 2, a temperature regulator valve 66 is arranged near the heat exchanger feed to ensure that air entering the ASM 12 is at an appropriate temperature.

FIG. 3 shows a detail arrangement for the MDC system 20. The MDC system 20 has an internal cooling loop 68. The internal cooling loop 68 draws cooling air from the intake 52 external to the OBIGGS 10. The cooling air passes though the internal cooling loop 68 and then may be cooled by the heat exchanger 28. Additionally, a bearing and rotor cooling loop 74 may draw air from the heat exchanger 28 outlet and may feed into the internal cooling loop 68.

Although example embodiments have been disclosed, a worker of ordinary skill in this art would recognize that certain modifications would come within the scope of the claims. For that and other reasons, the following claims should be studied to determine their true scope and content.

What is claimed is:

1. A motor driven compressor system for use in an on board inert gas generating system (OBIGGS), comprising:
- a motor including an internal cooling loop, wherein the internal cooling loop draws cooling air from outside the motor driven compressor system;
- at least one compressor driven by the motor; and
- a heat exchanger in fluid communication with the at least one compressor and the cooling loop and arranged in a ram air duct; and
- a fan arranged downstream from the heat exchanger in the ram air duct.

2. The motor driven compressor system of claim 1, wherein the at least one compressor comprises a first compressor and a second compressor.

3. The motor driven compressor system of claim 1, wherein the fan is an electric fan.

4. The motor driven compressor system of claim 1, wherein the ram air duct feeds into an overboard exhaust downstream from the fan.

5. The motor driven compressor system of claim 1, wherein the heat exchanger is an intercooler-type heat exchanger.

6. The motor driven compressor system of claim 1, further comprising a bearing and rotor cooling loop separate from the internal cooling loop.

7. The motor driven compressor system of claim 6, wherein the bearing and rotor cooling loop draws cooling air from an outlet of the heat exchanger.

8. The motor driven compressor system of claim 6, wherein the bearing and rotor cooling loop feeds into the internal cooling loop.

9. The motor driven compressor system of claim 1, further comprising an air separation module (ASM) configured to separate nitrogen-enriched air from oxygen-enriched air and in fluid communication with the heat exchanger.

10. An on board inert gas generating system (OBIGGS) for a gas turbine engine, comprising:
- an air separation module (ASM) configured to separate nitrogen-enriched air from oxygen-enriched air;
- a heat exchanger configured to cool air entering the ASM and arranged in a ram air duct; and
- a motor driven compressor system feeding air into the ASM, and including a first compressor and a second compressor driven by a motor and an internal cooling loop, wherein the internal cooling loop draws cooling air from outside the OBIGGS, wherein air from the first compressor feeds into an overboard exhaust at a first mixing point and oxygen-enriched air feeds into the overboard exhaust at a second mixing point.

11. The OBIGGS of claim 10, wherein a fan is arranged downstream from the heat exchanger and upstream from the overboard exhaust in the ram air duct.

12. The OBIGGS of claim 11, wherein the second mixing points is downstream from the fan.

13. The OBIGGS of claim 11, wherein the first and second mixing points are upstream from the fan.

14. The OBIGGS of claim 10, wherein air exiting from the internal cooling loop is cooled by the heat exchanger.

15. The OBIGGS of claim 10, further comprising a temperature regulator valve between the heat exchanger and the ASM.

16. A method of cooling an on board inert gas generating system (OBIGGS), comprising:
- providing a motor driving at least one compressor;
- providing a heat exchanger arranged in a ram air duct and configured to cool air passing to an air separation module (ASM) from the at least one compressor;
- providing a fan arranged downstream from the heat exchanger in the ram air duct;
- drawing cooling air from outside of the OBIGGS; and
- providing the cooling air to a motor cooling loop.

17. The method of claim 16, further comprising passing air exiting the cooling loop through the heat exchanger.

18. The method of claim 16, further comprising drawing additional cooling air from an outlet of the heat exchanger and providing the additional cooling air to a bearing and rotor cooling loop.

19. The method of claim 18, further comprising passing air exiting from the bearing and rotor cooling loop to the motor cooling loop.

20. The method of claim 16, further comprising regulating a temperature of the air passing to the ASM from the at least one compressor.

* * * * *